WHAT IS CLAIMED IS:

1. A controller for controlling an air-fuel ratio of an internal-combustion engine, comprising:

5   a first exhaust gas sensor for detecting oxygen concentration of exhaust gas;

a first decimation filter connected to the first exhaust gas sensor; and

a control unit connected to the first decimation filter, the control 10   unit configured to determine a manipulated variable for manipulating the air-fuel ratio so that an output value from the first decimation filter converges to a target value,

wherein the first decimation filter further comprises:

a first oversampler for oversampling the output of the first 15   exhaust gas sensor in a shorter cycle than a cycle that is used for determining the manipulated variable;

a first low-pass filter for smoothing the oversampled value; and

a first downsampler for re-sampling the smoothed value in 20   the cycle that is used for determining the manipulated variable to output the re-sampled value.

2. The controller of claim 1, wherein the control unit is further configured to perform response assignment control to determine the manipulated 25   variable.

3. The controller of claim 1, wherein the control unit is further configured to perform control that uses one of delta-sigma modulation algorithm, delta

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modulation algorithm and sigma-delta modulation algorithm to determine the manipulated variable.

4. The controller of claim 1, wherein an object to be controlled by the air-fuel ratio control is an exhaust system, the exhaust system comprising a catalyst converter and the first exhaust gas sensor, the first exhaust gas sensor disposed downstream of the catalyst converter,

wherein the control unit is further configured to:

determine a dead time in the exhaust system based on the output value from the first decimation filter;

calculate an estimate value for the output of the first exhaust gas sensor so that the dead time is compensated; and

determine the manipulated variable for manipulating the air-fuel ratio based on the estimated value.

5. The controller of claim 4, wherein the object to be controlled by the air-fuel ratio control further comprises an air-fuel ratio manipulating system extending from the control unit through the internal-combustion engine to a second exhaust gas sensor, the second exhaust gas sensor disposed upstream of the catalyst converter,

wherein the control unit is further configured to:

determine a dead time in the air-fuel ratio manipulating system; and

calculate the estimate value for the output of the first exhaust gas sensor so that the dead time in the exhaust system and the dead time in the air-fuel ratio manipulating system are compensated.

6. The controller of claim 4, wherein the control unit is further configured

to:

determine a parameter based on the output value from the first decimation filter; and

use the parameter for determining the manipulated variable,

5   wherein the parameter acts to adapt the manipulation of the air-fuel ratio to state changes of the exhaust system.

7. The controller of claim 1, wherein a cut-off frequency for the first low-pass filter is set to a higher frequency than a frequency that is used to

10   detect a failure of a catalyst converter.

8. A controller for controlling an air-fuel ratio of an internal-combustion engine, comprising:

a first exhaust gas sensor provided downstream of a catalyst

15   converter, the first exhaust gas sensor detecting oxygen concentration of exhaust gas;

a second exhaust gas sensor provided upstream of the catalyst converter, the second exhaust gas sensor detecting an air-fuel ratio of the exhaust gas;

20   a second decimation filter connected to the second exhaust gas sensor; and

a control unit connected to the second decimation filter, the control unit configured to determine a manipulated variable for manipulating the air-fuel ratio based on the output value from the second decimation filter so

25   that an output value from the first exhaust gas sensor converges to a target value,

wherein the second decimation filter further comprises:

a second oversampler for oversampling the output of the

second exhaust gas sensor in a shorter cycle than a cycle that is used for determining the manipulated variable;

a second low-pass filter for smoothing the oversampled value; and

5   a second downsampler for re-sampling the smoothed value in the cycle that is used for determining the manipulated variable to output the re-sampled value.

9. The controller of claim 8, wherein the control unit is further configured
10 to perform response assignment control to determine the manipulated variable.

10. The controller of claim 8, wherein the control unit is further configured to perform control that uses one of delta-sigma modulation algorithm, delta
15 modulation algorithm and sigma-delta modulation algorithm to determine the manipulated variable.

11. The controller of claim 8, wherein an object to be controlled by the air-fuel ratio control is an exhaust system, the exhaust system extending
20 from the second exhaust gas sensor through the catalyst converter to the first exhaust gas sensor,

wherein the control unit is further configured to:

determine a dead time in the exhaust system based on the output value from the second decimation filter;

25   calculate an estimated value for the output of the first exhaust gas sensor so that the dead time is compensated; and

determine the manipulated variable for manipulating the air-fuel ratio based on the estimated value.

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12. The controller of claim 11, wherein the object to be controlled by the air-fuel ratio control further comprises an air-fuel ratio manipulating system extending from the control unit through the internal-combustion engine to the second exhaust gas sensor,

wherein the control unit is further configured to:

determine a dead time in the air-fuel ratio manipulating system; and

calculate the estimated value for the output of the first exhaust gas sensor so that the dead time in the exhaust system and the dead time in the air-fuel ratio manipulating system are compensated.

13. The controller of claim 11, wherein the control unit is further configured to:

determine a parameter based on the output value from the second decimation filter; and

use the parameter for determining the manipulated variable,

wherein the parameter acts to adapt the manipulation of the air-fuel ratio to state changes of the exhaust system.

14. The controller of claim 8, wherein a cut-off frequency for the second low-pass filter is set to a higher frequency than a frequency that is used to detect a failure of a catalyst converter.

15. A method for controlling an air-fuel ratio of an internal-combustion engine, comprising the steps of:

(a) oversampling the output of an exhaust gas sensor, the exhaust gas sensor provided in an exhaust manifold of the engine;

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(b) low-pass filtering the oversampled value;

(c) re-sampling the filtered value; and

(d) determining a manipulated variable for manipulating the air-fuel ratio based on the re-sampled value,

wherein a sampling cycle used for the oversampling step is shorter than a cycle used for the determining step, and

wherein a sampling cycle used for the re-sampling step is the same as the cycle used for the determining step.

16. The method of claim 15, wherein the exhaust gas sensor is a first sensor for detecting oxygen concentration of exhaust gas flowing through the exhaust manifold, the first sensor provided downstream of a catalyst converter.

17. The method of claim 15, wherein the exhaust gas sensor is a second sensor for detecting an air-fuel ratio of exhaust gas flowing through the exhaust manifold, the second sensor provided upstream of a catalyst converter.

18. The method of claim 15, wherein the step (d) further comprises the step of performing response assignment control to determine the manipulated variable.

19. The method of claim 15, wherein the step (d) further comprises the step of performing one of delta-sigma modulation algorithm, delta modulation algorithm and sigma-delta modulation algorithm to determine the manipulated variable.

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20. The method of claim 16, further comprising the steps of:

determining a dead time based on the re-sampled value, the dead time being a time required for the air-fuel manipulation to be reflected in the output of the first sensor;

5   calculating an estimated value for the output of the first sensor so that the dead time is compensated; and

determining the manipulated variable for manipulating the air-fuel ratio so that the estimated value converges to a target value.

10   21. The method of claim 17, further comprising the steps of:

determining a dead time based on the re-sampled value, the dead time is being a time required for the air-fuel manipulation to be reflected in the output of a first sensor, the first sensor provided downstream of the catalyst;

15   calculating an estimated value for the output of the first sensor so that the dead time is compensated; and

determining the manipulated variable for manipulating the air-fuel ratio so that the estimated value converges to a target value.

20   22. The method of claim 15, further comprising the steps of:

determining a parameter based on the re-sampled value; and

using the parameter for determining the manipulated variable, the parameter acting to adapt the air-fuel ratio manipulation to state changes of an exhaust system of the engine.

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23. The method of claim 15, wherein a cut-off frequency for the low-pass filtering step (b) is set to a higher frequency than a frequency that is used to detect a failure of a catalyst converter.

24. A computer program stored on a computer readable medium for use in controlling an air-fuel ratio of an internal-combustion engine, the computer program comprising:

5   (a) program code for oversampling the output of an exhaust gas sensor, the exhaust gas sensor provided in an exhaust manifold of the engine;

        (b) program code for low-pass filtering the oversampled value;

        (c) program code for re-sampling the filtered value; and

10   (e) program code for determining a manipulated variable for manipulating the air-fuel based on the re-sampled value,

        wherein a sampling cycle used for the program code for oversampling is shorter than a cycle used for the program code for determining the manipulated variable, and

15   wherein a sampling cycle used for the program code for re-sampling is the same as the cycle used for the program code for determining the manipulated variable.

25. The computer program of claim 24, wherein the exhaust gas sensor is a

20 first sensor for detecting oxygen concentration of exhaust gas flowing through the exhaust manifold, the first sensor provided downstream of a catalyst converter.

26. The computer program of claim 24, wherein the exhaust gas sensor is a

25 second sensor for detecting an air-fuel ratio of exhaust gas flowing through the exhaust manifold, the second sensor provided upstream of a catalyst converter.

27. The computer program of claim 24, wherein the program code for determining the manipulated variable further comprises program code for performing response assignment control to determine the manipulated variable.

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28. The computer program of claim 24, wherein the program code for determining the manipulated variable further comprises program code for performing one of delta-sigma modulation algorithm, delta modulation algorithm and sigma-delta modulation algorithm to determine the

10   manipulated variable.

29. The computer program of claim 25, further comprising:

program code for determining a dead time based on the re-sampled value, the dead time being a time required for the air-fuel manipulation to

15   be reflected in the output of the first sensor;

program code for calculating an estimated value for the output of the first sensor so that the dead time is compensated; and

program code for determining the manipulated variable for manipulating the air-fuel ratio so that the estimated value converges to a

20   target value.

30. The computer program of claim 26, further comprising:

program code for determining a dead time based on the re-sampled value, the dead time is being a time required for the air-fuel manipulation

25   to be reflected in the output of a first sensor, the first sensor provided downstream of the catalyst;

program code for calculating an estimated value for the output of the first sensor so that the dead time is compensated; and

program code for determining the manipulated variable for manipulating the air-fuel ratio so that the estimated value converges to a target value.

5   31. The computer program of claim 24, further comprising:

program code for determining a parameter based on the re-sampled value; and

program code for using the parameter for determining the manipulated variable, the parameter acting to adapt the air-fuel ratio

10   manipulation to state changes of an exhaust system of the engine.

32. The computer program of claim 24, wherein a cut-off frequency used in the program code for low-pass filtering is set to a higher frequency than a frequency used to detect a failure of a catalyst converter.

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